Research Product 96-10

# Individual Combatant Simulation System (ICSS) Assessment Plan

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**August 1996**

**Simulation Systems Research Unit**

**U.S. Army Research Institute for the Behavioral and Social Sciences**

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The objectives of the ICSS program were to: insert the individual combatant into the Distributed Interactive Simulation (DIS) compliant virtual environment; develop a more accurate representation of hostile combatants, neutrals, and friendlies in a dynamic synthetic environment; and develop a more realistic human interface. This report describes the assessment plan for the ICSS. Included are descriptions of the objectives of the ICSS program, its components, the objectives of the ICSS assessment, and the scope of the assessment (in terms of the ICSS tasks that are included). Time constraints and assessment approaches are presented. The approach for the development of lessons learned, which applies to all ICSS tasks, is then described. Each ICSS task (and where appropriate, subtasks) is described along with the assessment issues, general assessment approach, type of approach, scenario, performance measures, and tasks necessary to conduct the assessment. The computer resources and requirements and resources of the participating organizations are then presented. Finally, a labor and cost estimate is provided for each task.

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## FOREWORD

The Individual Combatant Simulation System (ICSS) concept was originally derived from the independent research and development efforts of the Air Force Armstrong Laboratory Human Resources Directorate (AL/HR), the U.S. Army Research Laboratory Human Research and Engineering Directorate (ARL/HRED), the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI), the Marine Corps Systems Command (MARCORSYSCOM), and the Naval Air Warfare Center Training Systems Division (NAWC-TSD). In 1993, each of these organizations had research and development programs under way to improve various aspects of simulation for the individual combatant, whether fighter or maintainer. In June 1994, with the encouragement of the Defense Modeling and Simulation Office, these organizations entered into a cooperative agreement for joint conduct of the ICSS program.

The objectives of the ICSS program were to: insert the individual combatant into the Distributed Interactive Simulation (DIS) compliant virtual environment; develop more accurate representations of hostile combatants, neutrals, and friendly forces in a dynamic synthetic environment; and develop a more realistic human interface. ICSS will enhance the ability of the Department of Defense to train individual combatant and leader skills; conduct virtual prototyping of developmental items; and provide the ability to conduct development and analysis of system utility, maintainability, and human centered design.

This report presents a plan for the conduct of the assessment of the ICSS program. The plan was presented to the ICSS program manager in January 1996. While the ICSS program was terminated prior to the conduct of the evaluation, the plan nevertheless provides an approach to the evaluation of behavioral issues in virtual simulations that should be of valued to other researchers and program managers.

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INDIVIDUAL COMBATANT SIMULATION SYSTEM (ICSS) ASSESSMENT PLAN

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# INDIVIDUAL COMBATANT SIMULATION SYSTEM (ICSS) ASSESSMENT PLAN

## Introduction

### Purpose

The purpose of this document is to describe the assessment plan for the Individual Combatant Simulation System (ICSS) at a level of detail that makes it possible: to obtain consensus among program participants regarding assessment issues, approaches, and tasks; and to estimate the cost of the conduct of the plan.

### Organization of the Plan

The background section describes the objectives of the ICSS program, its components, and the goals of the ICSS assessment. The Scope of the Assessment, in terms of the ICSS tasks which are included, time constraints, and assessment approaches are presented. The approach for the development of lessons learned, which applies to all ICSS tasks, is then described. Each ICSS task (and where appropriate, subtasks) is then described along with the assessment issues, general assessment approach, type of approach, scenario, performance measures, and tasks necessary to conduct the assessment. The computer resources and requirements and resources of the participating organizations are then presented. Finally, a labor and cost estimate is then provided for each task.

## Background

The ICSS concept was derived from the originally independent research and development efforts of the Air Force Armstrong Laboratory Human Resources Directorate (AL/HR), the U.S. Army Research Laboratory Human Research and Engineering Directorate (ARL-HRED), the U.S. Army Research Institute (ARI), the Marine Corps Systems Command (MARCORSYSCOM), and the Naval Air Warfare Center Training Systems Division (NAWC-TSD). In 1993, each of these organizations had research and development programs under way to improve various aspects of simulation for the individual combatant, whether fighter or maintainer. MARCORSYSCOM sponsored NAWC-TSD's development of the Team Target Engagement Simulator (TTES), a squad-level tactical and marksmanship trainer based on the use of computer-generated environment.[1] Both AL/HR and ARL-HRED were sponsoring improvements in the use of articulated human figure models for concept development and system design. ARL-HRED had also initiated work to develop the Individual Soldier Mobility System (ISMS), a more natural human interface with simulated environments. ARI had a program of research under way to improve the use of virtual environments for individual combatant training, mission planning, and mission rehearsal. In early 1994, with the encouragement of the Defense Modeling and Simulation Office, these organizations entered into a cooperative agreement for joint conduct of the ICSS program.

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[1] At the current state of its development, TTES is limited to the simultaneous insertion of two individuals.

The objectives of the ICSS program are to: insert the individual combatant into the Distributed Interactive Simulation (DIS) compliant virtual environment; develop a more accurate representation of hostile combatants, neutrals and friendlies in a dynamic synthetic environment; and develop a more realistic human interface. ICSS will enhance the ability of DoD to train individual combatant and leader skills, conduct virtual prototyping of developmental items, and provide the ability to conduct development and analysis of system utility, maintainability and human centered design.

The ICSS program was initially proposed as a series of eight tasks of varying duration to be carried out during a two year period, with some tasks beginning in year one and some in year two. Each task had a government task leader, responsible for its conduct, and most tasks had a performing contractor. Tasks, task leaders, and performing contractors are shown in Table 1. The focus of the tasks was on the development of new capabilities, not their integration. Consequently, there is not a single ICSS. There are instead a number of different capabilities and products, in varying stages of development, which could potentially be integrated but which must be assessed independently.

## Approach to the ICSS Assessment

### Goals

The overall goals of the ICSS assessment are to:

> Demonstrate and document, both qualitatively and quantitatively, the extent to which ICSS technologies can enhance the training of the individual combatant and the development of doctrine, tactics, and systems for individual combatants.
>
> Identify areas of ICSS technology where future development is required.
>
> Document for future developers the "lessons learned" in the conduct of the component tasks.

Table 1

ICSS Tasks, Task Leaders, and Contractors

| | |
|---|---|
| Task 1: | DIS CONTROL OF ARTICULATED HUMAN FIGURE BEHAVIORS |
| Task Leader: | AL/HR |
| Contractor: | University of Pennsylvania |
| Task 2: | LINKING INDIVIDUAL COMBATANTS WITH COMPUTER CONTROLLED REPRESENTATIONS OF SQUAD/FIRE TEAM MEMBERS |
| Task Leader: | ARI |
| Contractor: | University of Central Florida Institute for Simulation and Training |
| Task 3: | SELECTED ACTIONS OF INDIVIDUAL NEUTRALS AND HOSTILE COMBATANTS |
| Task Leader: | NAWC-TSD |
| Contractors: | Naval Postgraduate School |
| Task 4: | DIS COMPUTER CONTROLLED HOSTILE COMBATANTS (CCHC) |
| Task Leader: | NAWC-TSD |
| Contractor: | University of Central Florida Institute for Simulation and Training |
| Task 5: | DIS CATALOGING AND AUDITING |
| Task Leader: | ARI |
| Contractor: | University of Central Florida Institute for Simulation and Training |
| Task 6: | HUMAN INTERFACE FOR DIS |
| Task Leader: | ARL-HRED |
| Contractor: | Sarcos Research Corporation |
| Task 7: | INDIVIDUAL COMBATANT HARDWARE SUITE |
| Task Leader: | Unfunded |
| Contractor: | Unfunded |
| Task 8: | ICSS ASSESSMENT |
| Task Leader: | ARI |
| Contractor: | To be Determined |

## Scope

The following ICSS tasks will be included in the assessment. Tasks numbers are taken from the ICSS Program Development Plan (PDP), dated 6 April 1994.

Task 1. DIS Control of Articulated Human Figure Behaviors. This work will develop and demonstrate the capability of using DIS to drive graphic representations of human figures through *Jack*, a software tool for manipulating and displaying articulated human 3-D forms. The task has two major subtasks; one involves the use of *Jack* in combat, and the other in maintenance.

Task 2. Linking Individual Combatants with Computer Controlled Representations of Squad/Fire Team Members. The purpose of this task is to develop the voice recognition and limb tracking technologies to control dismounted Semi-Automated Forces (SAFOR) combatants through verbal commands or hand and arm signals.

Task 3. Selected Actions of Individual Neutrals and Hostile Combatants. This task will identify and define techniques, tactics and behaviors employed by hostile combatants and neutrals and support the development of computer controlled hostile combatants and neutrals (CCHC/N) for virtual environments and DIS. Since the outcomes of this tasks will be incorporated directly into Task 4, they will be assessed as part of Task 4.

Task 4. DIS Computer Controlled Hostile Combatants (CCHC). This task will develop and implement computer controlled representations of hostile combatants to interact with the dismounted DIS trainee.

Task 5. DIS Cataloging And Auditing. This task will analyze the adequacy of DIS database requirements and networking protocols for the dismounted combatant in virtual environments.

Task 6. Human Interface for DIS. This task will develop a cost-effective mobility simulator that can be used for Virtual Battlefield Training by the Battle Labs and DIS. There are two components. The first is the development of the Individual Soldier Mobility Simulator (ISMS), which is developing the capability to simulate lower body movement. The second is developing an improved capability for TTES to track weapon position and upper body position accurately.

Two ICSS tasks have been excluded from this list. The first, Task 7, Individual Combatant Hardware Suite, is a hardware and software acquisition. The second, Task 8, is the assessment described in this report. Neither of these tasks is currently funded.

## Time Constraints

The following is a notional timeline based on these assumptions: all assessment activities must be completed prior to 30 September 1996; some form of contract support will be required for the conduct of most, if not all, task assessments; and the assessment will not be a one-time activity, but a series of events occurring over a period of time. The dates below describe the general time frame in which the assessments must be conducted.

Begin materials preparation (scenarios, environments, data collection instruments, etc.) -- Oct 95

Begin data collection -- Jan 96

Begin documentation -- Jul 96

Complete all tasks -- Sep 96

## Performance Method

The work will be performed as a series of tasks which can be carried out by either in-house government organizations (e.g., NAWC-TSD, ARL-HRED), the task contractor (e.g., the Institute for Simulation and Training, the University of Pennsylvania, etc.), an independent contractor, or a combination of the above. Each of these approaches has its strengths and weaknesses. The developing organization (government or contractor) is the most knowledgeable about the technology involved, but may not have the manpower or skills to develop the necessary materials and conduct the assessment. In addition, this would leave the integration of the individual task assessments undone. It is likely that no single independent contractor would have the required skills to conduct the entire assessment. A combination of developing organization and independent contractor could do all of the work, but would be the most difficult to manage and control.

## Types of Assessment Approaches

Given the diversity of the task objectives and the methods used to achieve them, several different approaches will be required. This section describes the approaches in general and then identifies which approaches are feasible for each task.

### Lessons Learned

It is anticipated that one of the most useful types of results that can be obtained from an ICSS will be the "lessons learned" from the development process. This includes not only what worked, but what did not. For example, in the area of control of direction of movement, NAWC-TSD has rejected an approach that involved a pressure-sensitive ring on the floor, and ARI has rejected an approach that involved tracking shoulder position. It is important to document why these approaches were terminated. The assessment of each task will include lessons learned. It is expected that lessons learned will be documented by the responsible government organization and/or developing contractor, with input from and coordination with the other activities involved in the performance of that task, whether government or contractor.

Technical/User/Subject Matter Expert (SME) Review

Technical experts can review and assess reports, plans, and technical documentation to assess their soundness and quality. Representative users (soldiers and trainers) and SMEs can provide a variety of information about a system or component in structured situations without the necessity of conducting a full-scale human in the loop experiment. Issues that can be assessed in this manner include the realism of a simulation or human figure, the similarity of different environments or objects, the appropriateness of various tactical or maintenance behaviors, and user acceptability. The important information that comes from user acceptability is an identification of the strengths and apparent weaknesses of a system. While user acceptance does not guarantee that a system will train successfully, a lack of user acceptance usually constitutes a major obstacle to successful implementation and utilization in the field.

Human in the loop evaluations

A critical aspect of the assessment will be the human in the loop evaluations. Four types of soldier in the loop evaluations are possible.

Real world vs virtual world performance. If ICSS technology is to be used to evaluate new doctrinal or equipment concepts (for example, providing each squad member with a radio, improved load-bearing equipment, or an improved anti-personnel weapon), then it needs to be shown that performance in the simulation is similar to performance in the real world, not for all aspects of the simulation, but for those derived from the requirements. For example, if accurate simulation of movement rates is required, a squad should not move tactically at radically different rates in the simulation and in the real world. If accurate simulation of small arms fire is important, then an individual's marksmanship performance in the simulation should be closely related to their marksmanship performance in the real world. If accurate simulation of maintenance performance is important, then component part accessibility and task completion times should be close to those found in the real world.

Training effectiveness and transfer. If ICSS technology is to be used to train soldiers or marines to perform combat tasks, then it needs to be shown that performance improves with practice in the simulation, and that practice in the simulation improves performance of the task in the real world. As an example, the voice and gesture recognition system could be used to train a soldier to control a fire team moving tactically. A group of trainees could be put through a short training sequence, perhaps consisting of a series of scenarios, with SME trainers providing feedback. Improvement could be assessed, using ratings by SMEs or objective performance measures. Pretests and post-tests consisting of field exercises could be used to assess transfer to the real world. This assessment is probably the most difficult and resource-consuming (time and money) to conduct.

Critical interface issues. It is anticipated that discussions among task leaders will identify soldier interface questions that can be resolved by human in the loop evaluations. These may include such things as the advantages of various forms of movement control, display devices, etc. Evaluations can be performed in conjunction with the performance and training effectiveness evaluations, or as stand-alone experiments.

Side effects and after effects. Simulator sickness has been identified as a potential problem with the use of Virtual Environments for training. Generally accepted and easily administered methods for measuring its severity exist. Although it is not anticipated that any experiments would be conducted solely for the purpose of collecting data on simulator sickness, simulator sickness data should be collected as part of all human in the loop experiments. The Simulator Sickness Questionnaire (SSQ; Kennedy, Lane, Berbaum, & Lilienthal, 1993) provides a generally accepted means of assessing simulator sickness.

The purpose of the human in the loop evaluations is to obtain data to support future design and development. They are not intended to serve as "Go/No Go" tests.

### Assessment Approaches Matched to Tasks

Table 2 shows the assessment approaches proposed for each task. A detailed discussion of the proposed assessments for each tasks will follow in a later section.

## Approach to the Development of Lessons Learned

The documentation of lessons learned will be a part of the task assessment for every task. These lessons learned will normally be developed by the government task leader and the developing contractor. The following types of lessons learned are to be included:

Technical approaches that did not work, and if known, the reasons why. This should include hardware, software, networking, and human-computer interface.

Undocumented characteristics of off-the-shelf hardware and software.

Successful short cuts.

Lessons learned about using VR for training, human performance measurement, and experimentation.

Management and scheduling of VR development.

Table 2

Assessment Approaches for Each Task

| Task | Assessment Approach | | |
|---|---|---|---|
| | Lessons Learned | Human in the Loop | Technical/ User/SME Review |
| 1A - *Jack* Combat | Y | Y | N |
| 1B - *Jack* Maintenance | Y | N | Y |
| 2 - Voice/Gesture | Y | Y | Y |
| 4 - CCHC (Includes Task 3) | Y | Y | Y |
| 5 - Human Figures/DIS | Y | N | Y |
| 6A - ISMS | Y | Y | N |
| 6B - Upper Body Tracking | Y | Y | N |

Y = Yes N = No

The sequence of activities to develop the lessons learned will be as follows.

Government task leader and developing contractor develop draft lessons learned for their task(s).

Government task leader and developing contractor present their lessons learned at a contractor-run conference held specifically for the purpose of disseminating these lessons learned within the ICSS community and identifying those general lessons learned that apply across multiple tasks.

Government task leader and developing contractor develop a written report chapter describing their lessons learned.

Contractor organizes and integrates chapters, and adds an introduction and conclusions, to produce a final lessons learned report.

Individual Task Assessment Plans

## Task 1A. DIS Control of Articulated Human Figure Behaviors: Combat

### Task Description

This task will develop and demonstrate the capability of using DIS to drive graphic representations of human figures through *Jack*, a software tool for manipulating and displaying articulated three-dimensional human forms.

The use of a distributed network involves multiple individuals interacting with each other while not co-located. The DIS communication protocols are designed to provide sufficient information for one DIS node to graphically represent the behaviors of a human figure (whether controlled by an actual human or computer software) at another DIS node. The following behaviors and states for human figures are being addressed: (1) stance (upright, kneeling, or prone), (2) movement (heading and velocity), (3) impact of injury or dead , (4) status of weapons (stowed and deployed), (5) identity (friendly, hostile, and neutral), (6) use of articulated objects (doors and windows), (7) use of movable objects (rocks, chairs), (8) use of hand tools and (9) use of common support equipment (for modeling ground maintenance activity).

In behaviors 1 - 4, *Jack* will provide for the transition between DIS posture conditions. For example, when the "upright" state changes to a "kneeling" state, *Jack* will provide a smooth transition of the human figure between these two postures. In behavior 5, *Jack* will provide various types of clothing to represent friendlies, hostile combatants, and neutrals. DIS does not yet have precisely defined methods for communicating behaviors 6 - 9, and *Jack* does not have the ability to portray them in fine detail. Extensions to DIS and *Jack* will be built to accommodate the need to model a wider range of human behaviors during the second year of work on this task. These extensions will be embedded in new/modified network communication protocols that permit efficient control of human behaviors over DIS.

The approach that *Jack* development has taken to satisfy behaviors 1 through 4 while maintaining an acceptable rate of speed of actions is a combination of a motion library and level of detail modeling. The motion library is based on the fact that the DIS entity state protocol data unit (PDU) can recognize only a limited number of static postures: standing, kneeling, prone, or dead. For the first three of these, the weapon can be either stowed or deployed. The University of Pennsylvania has developed posture graphs (see Figure 1, for example) which show the possible transitions among the available postures. For simplification, direct transitions among all possible postures are not possible. For example, a crawling figure which was "killed" would transition first to a prone deployed posture, then to a dead posture, rather than going directly from crawling to dead. Three animation sequences, using different level of detail models, are then developed for each of these possible transitions. The level of detail models, called human-1, human-2, and human-3, differ in terms of a variety of characteristics (see Table 3). The choice of level of detail models is dependent on the distance of the observer to the figure.

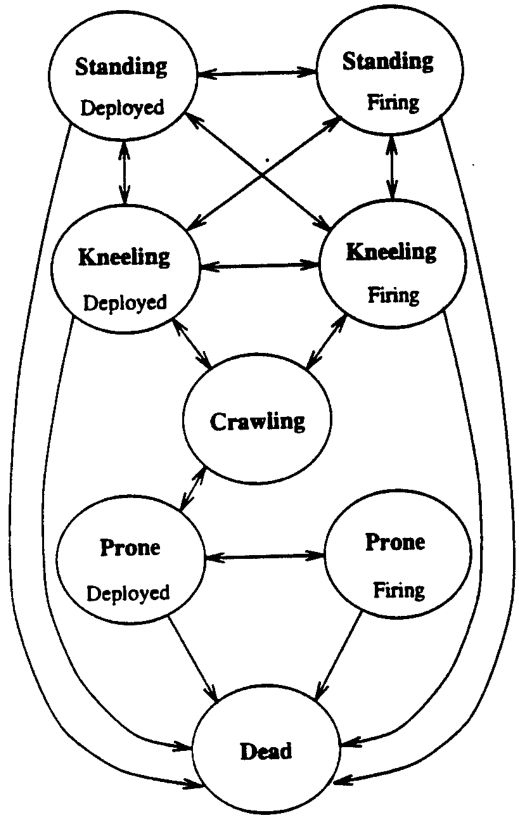


Figure 1. The static posture graph (from Granieri, Crabtree, & Badler, 1995).

As described by Reece (1994), and shown in Figure 2, there are five different representations of the trainee's human figure in DIS: (1) the true position; (2) the position as measured by sensors; (3) the position as reported in the DIS PDUs transmitted over the network; (4) the position as interpolated by the receiving simulator platform; and (5) the position as rendered on the display of the receiving platform. Each transformation introduces possibilities for position and temporal errors. This could be particularly important for combat simulations, where the errors could well affect whether or not a human figure is visible, or even hit or killed.

Assessment Issues

Are the actions and appearance of DIS-driven human figures discernibly different when their actions are driven by an instrumented human and when their actions are driven by computer models? By discernibly different we mean: can human observers detect a difference (at different distances); does the speed with which selected movements are made differ?

Do the different level of detail *Jack* models differ in terms of their likelihood of introducing location errors?

What are the appropriate ranges for the use of each of the level of detail models?

Table 3

The Different Levels for Detail for the Human Figure Models

| | Human-1 | Human-2 | Human-3 |
|---|---|---|---|
| Polygons | 2400 | 500 | 120 |
| Rigid Segments | 69 | 19 | 12 |
| Joints | 73 | 17 | 11 |
| DOFs | 134 | 50 | 21 |
| Motion (Hz) | 60 | 30 | 15 |

Taken from Granieri, Crabtree, and Badler (1995)

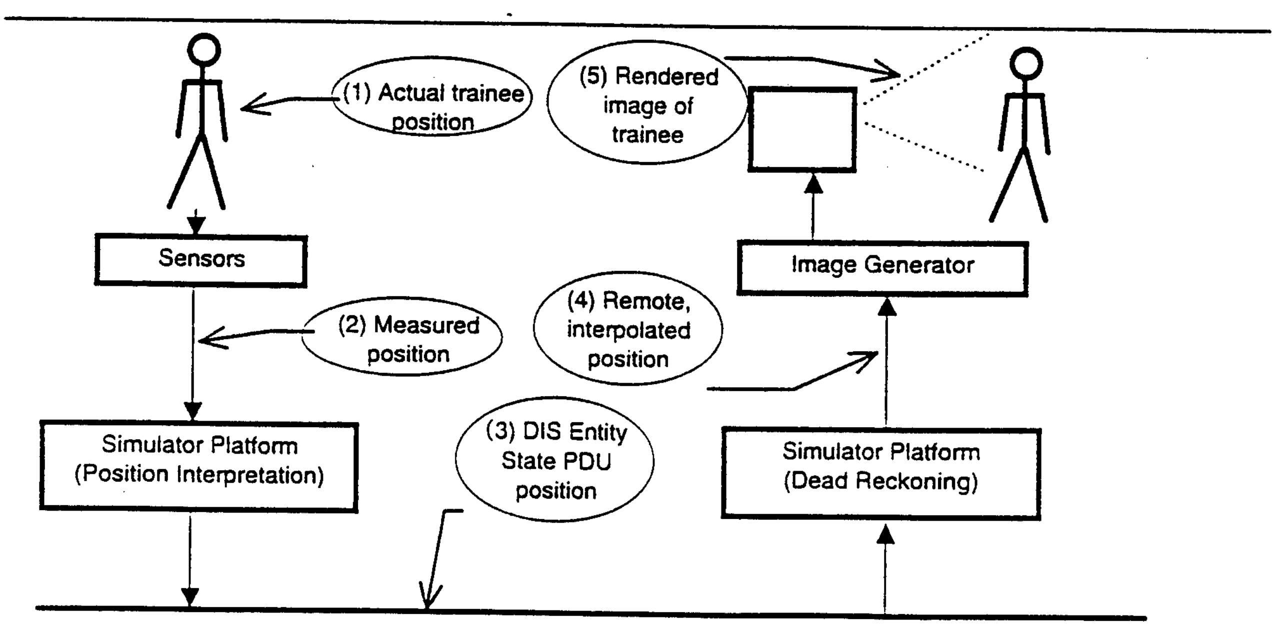


Figure 2. Five forms of entity state representation in a DIS system (from Reece, 1994).

General Assessment Approach

A human in the loop experiment (1.A.) will be conducted to address these issues. A series of short segments from a combat scenario will be prepared. Each segment will consist of a human figure performing an action. The action will be performed by either *Jack* or an instrumented human. Recordings of each of these actions will be converted to DIS PDUs and the PDUs will be used to drive each of the three *Jack* level of detail models. The actions of the "live" humans will also be videotaped for later comparisons. Human observers will be asked to determine whether each recording shows control of the figure by a human or a computer. Discrepancies in the positions of the key body parts (such as head, hands, and feet) between the originating and receiving platform will be compared. The occurrence of such "impossible" events as floating in the air or sinking into the ground will be determined by technical experts.

A very large number of different observations are possible. Human observers could view each single action under 48 different conditions. Each action can be performed by two types of figure control (human or computer), three level of detail models, at three different distances and from three different orientations relative to the figure (front, side, or rear). The distances will be selected based on preliminary experimentation, but are expected to be between 25 and 150 meters.

Four different types of human figure activities can be examined with this approach:

Posture Transitions. Each scenario segment will consist of a human figure performing a simple posture transition (either standing to kneeling, standing to prone, kneeling to standing, kneeling to prone, prone to standing, or prone to kneeling). Human observers will view and categorize as human-or computer-controlled 288 segments (48 times for each transition).

Movement. Each scenario segment will consist of a human figure either running, walking forward, walking backward, or crawling. Human observers will view and categorize as human- or computer-controlled 192 segments (48 times for each type of movement).

Obstacle Avoidance. Each scenario segment will consist of a walking human figure changing direction to avoid an obstacle, then returning to the original direction of movement. Human observers will view and categorize as human- or computer-controlled 48 segments.

Weapons Firing. Each scenario segment will consist of a human figure firing a weapon (M16) from either a standing, kneeling, or prone position. Human observers will view and categorize as human- or computer-controlled 144 segments.

One of the critical activities in preparing for this experiment will be to reduce the number of possible observations to a reasonable number (approximately 100) while still providing an adequate sampling of distances, activities, positions, and orientations.

Scenario and terrain database

Short combat segments in the Quantico Combat Training Village or the ARI open terrain database.

Performance Measures

Ratings of Figure Similarity
Simulated Position Discrepancies
Polygons generated per unit time

Assessment Tasks: Experiment 1A.

Task 1A.1. Develop Scenario or Scenario Segments. From the 672 different scenario segments described above, select approximately 100 for inclusion in the experiment. Develop both *Jack*-controlled and human-controlled versions of each segment.

Task 1A.2. Develop and test Experimental Control and Data Collection Software. This software will control the presentation of the video segments, time and record the subject's responses (if entered directly into the computer), and create a datafile for further analysis.

Task 1A.3. Develop Experimental Procedures and Materials (data collection forms, instructions for Subjects, etc.). This should include the development of forms for collecting background information, vision testing, and preparation of the necessary documents for approval of the use for human subjects.

Task 1A.4. Conduct Experiment.

Task 1A.5. Analyze Data.

Task 1A.5.a. Analyze Human Performance Data (accuracy and speed of human subject responses).

Task 1A.5.b. Analyze Hardware/Software Performance Data (position discrepancies between send and receive nodes).

Task 1A.6. Write Report.

## Task 1B. DIS Control of Articulated Human Figure Behaviors: Maintenance

### Task Description

This task shares many aspects of task 1A, except that the focus is on the use of human figure models (specifically *Jack*) for maintenance, rather than combat tasks. As noted previously, the more challenging modifications and extensions of DIS and *Jack* are needed more for this application than for the combat scenario. Important behaviors are: use of articulated objects (doors and windows), movable objects (rocks, chairs), hand tools, and common support equipment. The intended use of the human figure model is also different. *The intended use of Jack* in maintenance applications is to support the design of new maintenance systems and procedures. Thus whether the human figure "looks like" an actual human is relatively unimportant. The crux of the issue is whether the use of *Jack*, in conjunction with a model of the system or equipment to be evaluated or tested, can predict human performance accurately enough to lead to appropriate design decisions.

### Assessment Issues

Is the behavior of actual humans and *Jack* models (when driven by appropriate task models) sufficiently similar to result in the same system design decisions or maintenance procedures? Specifically, are task completion times similar, are the sequences of actions taken similar, and are the same actions possible (i.e., accessibility)?

### General Assessment Approach

This assessment needs to be done with an existing system, not a conceptual system, so that actual human performance data can be collected and compared with *Jack* performance data. It may not be necessary to use a complete system, but there should be a reasonable sampling of the types of tasks on which *Jack* is expected to be used. It may also be possible to use high fidelity mock-ups or simulators in place of the actual equipment in order to obtain human performance data. Either approach, or a combination of both, should suffice. In either case, the first step is to measure the performance of several different humans on the task. Next measure *Jack* performance on the same tasks. Use maintenance SMEs to judge the similarity of *Jack* and human performance. In addition, make objective comparisons of task completion times and sequences of actions. Unlike task 1A, in Task 1B similarity refers to the sequence and timing of maintenance actions, not to similarity of appearance. The assessment needs to focus on those new capabilities that are being added to *Jack* as part of the ICSS effort.

A potential problem with this approach is that no standards currently exist for how similar human performance and *Jack* performance need to be. With use of multiple humans, and multiple runs with *Jack*, performance distributions could be obtained for both, and statistical tests run, but sufficient runs to make these tests meaningful may not be possible. Possibly, objective standards could be derived from SMEs or constructive models. Because of the complexity of this assessment, a three-phase approach (initial small-scale assessment, revision of models and assessment procedures, and final large-scale assessment) is recommended.

Scenario Terrain Database

Maintenance performance at an air base.

Performance Measures

SME Ratings of similarity of performance
Task action sequences
Task times

Assessment Tasks

Task 1B.1. Develop maintenance scenario or scenario segments. Subtasks will include: the selection of the system or the tasks that are to be the focus of the assessment; the development of the task models to drive *Jack*; and obtaining or developing the equipment, simulators, or mock-ups that will be used by the human maintainers.

Task 1B.2. Execute selected maintenance scenarios using *Jack*. Record data on task sequences and task completion times.

Task 1B.3. Execute selected maintenance scenarios using actual maintenance technicians. Record data on task sequences and task completion times.

Task 1B.4. Develop experimental procedures and materials (procedure similarity rating schemes, task standards, data collection forms, instructions for SMEs, etc.).

Task 1B.5. Use SMEs to judge similarity of *Jack* and human maintenance technician procedures.

Task 1B.6. Analyze Data.

Task 1B.6.a. Analyze SME Rating Data

Task 1B.6.b. Analyze Objective Performance Data

Task 1B.7. Write Report.

## Task 2. Linking Individual Combatants with Computer Controlled Representations of Squad/Fire Team Members

### Task Description

The purpose of this effort is to develop a prototype of a more realistic interface for the dismounted squad or fire team leader in the DIS battlefield environment. The emphasis in DIS to date has been on the simulation of combat for soldiers fighting from vehicles, not for dismounted soldiers. However, the cluster of technologies generally referred to as Virtual Environment (VE) technology has the capability to integrate the dismounted soldier more fully into DIS. This effort will produce a prototype system using voice recognition and limb tracking technologies to enable a squad or fire team leader to control dismounted Computer-Generated Forces (CGF) combatants (representing squad or fire team members) through a set of verbal commands and hand and arm signals. The commands implemented are shown in Figure 3. This approach will permit training the small unit leader in those decision-making, communication, and leadership skills in a realistic environment with the necessity of equipping an entire squad of soldiers.

| Helicopter Gesture Commands | Squad Voice Commands | Squad Gesture Commands |
|---|---|---|
| Prepare for Guidance | Fire/Move/Rush | Form Column |
| Forward | There | Form Line |
| Backward | Now/When he | Form Wedge |
| Move Right | Fires/Moves/Rushes | Close Up |
| Move Left | | Open Up |
| Upward | | Disperse |
| Downward | | Increase Speed |
| Land | | Decrease Speed |
| | | Change Direction |
| | | Point to |
| | | Look at |
| | | Commence Firing |
| | | Cease Firing |

Figure 3. Voice and gesture commands.

Commercial off-the-shelf hardware and software is being used for the voice recognition subsystem. The gesture recognition subsystem requires the development of completely new software and modifications to existing hardware. Position of the arms (relative to the torso) is tracked using three electromagnetic trackers. Specially designed gloves are used to determine whether the hands are open or closed. The software recognizes both dynamic and static gestures, and is expandable in terms of the number of gestures that can be recognized. The Computer-Generated Forces Testbed (CGFT) is being modified to receive the voice and gesture commands. A DIS interface is being developed so that the soldier interface can communicate with CGFT.

Assessment Issues

How accurately are commands (both voice and gesture) recognized as a function of individual characteristics (body size, practice, skill or experience in using gestures for command and control)?

Does skill in giving gesture commands improve with practice?

Does tactical proficiency improve with practice?

Does the simulated friendly force, at the unit level, respond appropriately given the tactical situation and the commands given?

General Assessment Approach

Two human in the loop experiments will be conducted. The first (Experiment 2.1) will address the first two issues. The second (Experiment 2.2) will address the last two issues. In the first experiment, an instrumented human (the trainee) will serve as a squad or fire team leader in a combination of short combat scenarios. Scenarios could be Military Operations in Urban Terrain/Military Operations in Built-up Areas (MOUT/MOBA) maneuvering and engaging targets but should also involve assumption of various movement formations. The leader will be videotaped and his voice commands recorded during the conduct of the scenario. Recordings will be made of each gesture/command as interpreted by the computer, and these will be compared with the interpretations of human judges based on the videotapes. Using these data, it will be possible to look at voice and gesture recognition performance as a function of a number of variables. The initial experiment will compare inexperienced (college students) with experienced (military personnel) leaders and will also examine the effects of practice with the system on performance.

In the second experiment, the system will be used to train tactics and command and control to Army Reserve Officers Training Corps (ROTC) students or other leader trainees. This would use the same tactical scenarios as the first experiment, but would look at the changes in tactical proficiency over time as assessed by SMEs. At the same time, the SMEs could assess the appropriateness of the simulated friendly forces given the commands and the tactical situation.

Scenario and Terrain Database

Combat scenario using the ARI Rural Terrain or Quantico Combat Training Village database.

Performance Measures

Gesture Recognition Accuracy
Tactical Proficiency (SME Ratings)
Appropriateness of CGF behaviors (SME Ratings)

Assessment Tasks: Experiment 2.1

Task 2.1.1. Develop Scenarios. These will be a series of relatively short combat or movement scenarios.

Task 2.1.2. Develop and test Experimental Control and Data Collection Software. This software will control the presentation of the scenarios, and record the subject's limb positions and how they were interpreted as gestures in a datafile for further analysis.

Task 2.1.3. Develop Experimental Procedures and Materials (data collection forms, instructions for Subjects, instructions for judges, etc.). This should include the development of forms for collecting background information, vision testing, and preparation of the necessary documents for approval of the use for human subjects.

Task 2.1.4. Conduct Experiment.

Task 2.1.5. Analyze Data.

Task 2.1.6. Write Report.

Assessment Tasks: Experiment 2.2

Task 2.2.1. Develop Scenarios It should be possible to use the same scenarios as were used in Experiment 2.1. However, some modifications may be required.

Task 2.2.2. Develop and test Experimental Control and Data Collection Software. Again, the control software used in Experiment 2.1 should suffice, with minor modifications.

Task 2.2.3. Develop Experimental Procedures and Materials (data collection forms, instructions for Subjects, etc.) This should include the development of forms for collecting background information, vision testing, and preparation of the necessary documents for approval of the use for human subjects.

Task 2.2.4. Conduct Experiment.

Task 2.2.5. Analyze Data.

Task 2.2.6. Write Report.

## Task 4. DIS Computer Controlled Hostile Combatants (CCHC)

(Note: This plan assumes that products from TASK 3, SELECTED ACTIONS OF INDIVIDUAL NEUTRALS AND HOSTILE COMBATANTS, will have been incorporated into Task 4, and that no separate assessment of Task 3 products will be performed.)

### Task Description

This task will identify and define techniques, tactics and behaviors employed by hostile combatants and neutrals for virtual environments and DIS. The types of combatants which the infantryman will encounter, and the actions of these various types of combatants will be considered. Hostile combatants range from the untrained civilian carrying a weapon, to the soldier who has received general training, to the highly trained warrior. Hostile actions can be broken down into basic behaviors, techniques, and tactics. Basic behaviors are physical movements such as running, carrying a weapon, and crouching. Techniques are those behaviors used in a tactical manner, such as running while maintaining cover, carrying a weapon in a manner that allows rapid use of the weapon, and crouching behind structures that offer concealment and cover. Tactics are coordinated group actions made to achieve tactical goals.

Computer controlled representations of hostile combatants will be developed and implemented to interact with the dismounted DIS trainee. The Institute for Simulation and Training (IST) CGFT will serve as the basis of this effort. The CGFT currently models each individual of a rifle squad that engages armored vehicles. These CCHCs will be adapted to engage individual combatants rather than vehicles.

The general architecture provides for a DIS-compatible distributed network consisting of multiple TTES stations and a single CCHC station. Both the TTES and CCHC nodes contain a database of the geographical region in which the exercises occur (i.e., Quantico Combat Training Village). The overall technical approach is to modify the SAFOR version of the CGFT. Areas that will require extensive modifications to meet the requirements of TTES include the physical modeling modules (e.g., line of sight, detection, and weapons effects), behavior generation (e.g., route planner for inside buildings, specific tactical behaviors occurring in urban conflicts), and the capability to run fully autonomously.

## Assessment Issues

There are two classes of assessment issues. The broad assessment issue is concerned with the contribution of the CCHC to the training effectiveness of the overall system of which it is a part (in this case, TTES). The specific assessment issues are concerned with the functioning and effectiveness of specific CCHC capabilities.

The broad assessment issue is whether CCHC enhances the practice and learning of tactically correct behavior by marines and soldiers. While this is the critical CCHC issue, it is difficult to assess accurately. The CCHC is one component, and only one component, of a larger training system. The visual depiction of the terrain database, the characteristics of objects in the database, and the representation of the dynamic processes (e.g., structures vs. munitions) in the simulated environment, as well as the characteristics of the trainee interface with the system and the instructional strategies employed (e.g., AARs) also influence training effectiveness. Therefore, a comparison of TTES with some other training approach does not adequately address the contribution of CCHC to training effectiveness. A comparison of two versions of TTES, with and without CCHC, or with different versions of CCHC, is required.

Specific assessment issues are:

Can the environment be represented in a manner which makes it possible for computer-controlled entities to extract tactical information?

Can the CCHC drive human figure models through DIS?

Is the CCHC behavior tactically sound? (The emphasis should be more on how well it fits common sense rules of behavior than tactical sophistication.)

Do the CCHC perception and weapons models result in realistic behavior?

Is the performance of CCHC interruptable, believable, and indistinguishable from human-driven icons?

## General Assessment Approach

The broad assessment issue is in many ways more suitable for empirical assessment than the specific ones. The general approach proposed for its resolution is to place a number of teams or small units through repetitions of a tactical (MOUT) scenarios, with sufficient variations so that the scenario cannot be learned, and assess changes in performance with practice. One-half of the groups of trainees will train against a sophisticated CCHC (tactically sound behavior, realistic perception model, and realistic weapons effects). The other half will train against a rudimentary version of the CCHC (limited tactical capabilities, simple perception model, and simple weapons effects). Both groups will then be tested in an instrumented live combat scenario against a live opponent in the Quantico Combat Training Village (using MILES), or, as a less desirable alternative, a TTES scenario against the sophisticated CCHC. Both expert ratings and objective measures of performance will be obtained.

Whether or not the environment can be represented in a manner which enables the CCHC to extract tactical information, and whether the CCHC can drive human figure models through DIS are issues more suitable for assessment as lessons learned, rather than empirical assessments. The remainder of the focused issues can be best addressed by using SMEs to view the behavior of the CCHC in highly structured scenarios and situations. Examples of the behaviors that might be used are:

Immediately move to the nearest covered or concealed position upon receiving fire;

Plan and execute a route to a designated location;

Plan and execute a covered or concealed route to a designated location;

From a defensive position, fire upon an attacking enemy as soon as he is detected;

From a prone position, rise and "run" into a nearby doorway; and

Follow another squad or team member.

The SMEs will rate the appropriateness of the CCHC tactical behavior, and the realism of the CCHC behavior/movements. For comparison purposes, ratings of human-driven icons performing the same movements will also be obtained.

<u>Scenario Terrain Database</u>

Combat (MOUT) scenario using the Quantico Combat Training Village

<u>Performance Measures</u>

SME Ratings of Tactical Performance
Tactical Mission Accomplishment
Survivability or Loss Ratio
Hits/Shots & Kills/Shots
Engagement Times & Ranges

<u>Assessment Tasks: Experiment 4.1</u>

<u>Task 4.1.1.</u> Develop Scenarios and Rudimentary CCHC. The scenarios should be multiple variations on a common training objective or drill, such as responding to contact with the enemy

or employing overwatch to move through an area. The rudimentary CCHC should possess less sophisticated capabilities than the CCHC currently available at the time of the evaluation. For example, the rudimentary CCHC might not incorporate target motion in determining whether or not a target is detected, or might not include own firing position (e.g., standing, prone) in calculating hit probabilities.

Task 4.1.2. Develop and test Experimental Control and Data Collection Software. This software will control the presentation of the scenarios, and the recording of the participant's actions, to include movements, rounds fired, hits, kills, etc., and create a datafile for further analysis.

Task 4.1.3. Develop Experimental Procedures and Materials (data collection forms, instructions for Subjects, etc.). This should include the development of forms for collecting background information, vision testing, and preparation of the necessary documents for approval of the use for human subjects.

Task 4.1.4. Conduct Experiment.

Task 4.1.5. Analyze Data.

Task 4.1.6. Write Report.

Assessment Approach: Experiment 4.2

Task 4.2.1. Develop Scenario Segments. This will include the selection of the CCHC behaviors to be addressed, and the creation of each of those scenarios using both human controlled and computer-controlled hostiles.

Task 4.2.2. Develop and test Experimental Control and Data Collection Software. This software will control the presentation of the video segments, time and record the subject's responses (if entered directly into the computer), and create a datafile for further analysis.

Task 4.2.3. Develop Experimental Procedures and Materials (data collection forms, instructions for Subjects, etc.) This should include the development of forms for collecting background information, vision testing, and preparation of the necessary documents for approval of the use for human subjects.

Task 4.2.4. Conduct Experiment.

Task 4.2.5. Analyze Data.

Task 4.2.6. Write Report.

## Task 5. DIS Cataloging and Auditing

### Task Description

This task will analyze the adequacy of DIS database requirements and networking protocols for the dismounted combatant in virtual environments. DIS has established standards for networking, protocols, database requirements, and environmental factors. They have not been specifically applied to dismounted combatants operating in distributed synthetic environments. There is currently no systematic examination or consensus within the DIS community regarding the adequacy of current DIS standards to support representation of the dismounted combatant. A systematic examination requires detailed analysis and evaluation of the requirements to transmit information about the behavior of dismounted combatants generated by the work conducted under the other tasks; comparison of the requirements with the capability of the current DIS protocol structure; and the development and promotion of solutions which resolve the discrepancies.

### Assessment Issue

Are the proposed approaches for modifying DIS standards to accommodate human figure requirements: (a) consistent with existing or proposed DIS standards; and (b) adequate to satisfy other non-ICSS requirements for the use of human figures in DIS?

### General Assessment Approach

The draft position paper resulting from this approach will be reviewed sequentially by: (a) task leaders and their performing contractors; (b) the members of the DIS Standards Human Figures Special Interest Group; and (c) appropriate DIS standards Working Groups after it has been prepared as a position paper. Prior to the start of the formal assessment, the task leaders and their performing contractors will have reviewed and commented on the draft position paper, and it will have been disseminated electronically to members of the DIS Standards Human Figures Special Interest Group.

### Scenario and Terrain Database

N/A

### Performance Measures

N/A

Assessment Tasks

Task 5.1. Present position paper at DIS Standards Conference and revise based on feedback.

Task 5.2. Prepare formal position paper and coordinate it with the DIS Standards Committee and other DIS Standards Working Groups.

## Task 6A. Human Interface for DIS

Task Description

An essential element of this effort is the design and fabrication of a single prototype of an Individual Soldier Mobility Simulator (ISMS). Currently, an individual soldier interacts with distributed simulations using a hand driven haptic device such as a spaceball or joystick. Neither these devices nor powered treadmills allow free, natural movement of the combatant's hands and feet, synchronized with terrain, in a virtual environment. To address this deficiency, a lower torso manipulator worn by or affixed to the combatant and responsive to digital commands generated by a simulator is required. The device will supply information to the simulation indicating the combatant's movements through the virtual terrain. The mobility simulator will allow unrestricted joint movements so that the natural feel of walking or running on terrain is simulated by arresting foot movement in synchrony with foot impacts on the virtual terrain. The system will allow the combatant to move naturally in all directions (three degrees of translational freedom), providing six degrees of freedom (DOF) total (three translational DOF per foot) and accommodate the 5th to 95th percentile soldier. The system will also allow the combatant the full use of his hands. This task will develop a cost-effective mobility simulator that can be used for virtual battlefield training by the Battle Labs and DIS. Two mobility simulators have been or are being developed as part of this effort. The first, the I-Port "Quick Fix" system, is a pedestal mounted, pedal-driven simulator. The second, the ISMS, will permit a more natural walking motion, based on different technology.

Assessment Issue

How does energy expenditure using the I-Port "Quick Fix" pedal driven system and the Individual Soldier Mobility Simulator" compare with energy expenditure while performing the same tasks in the real world?

General Assessment Approach

A series of human in the loop experiments will be conducted to:

Compare energy expenditure while walking at varying speeds and inclines using the I-Port Quick Fix system (pedestal mounted and pedal-driven) with that predicted by empirically-based models:

Compare energy expenditure and movement rates using the I-Port Quick Fix and ISMS while traversing simulated obstacle courses with real world energy expenditure.

Scenarios and Terrain Databases

None required for the first experiment. Two courses (the K-D Range, a relatively short course with many obstacles, and a longer cross country course) for the second.

Performance Measures

Course completion time
VO2 (Oxygen consumption)

Assessment Tasks: Experiment 6A.1

Task 6A.1.1. Develop Scenarios. The scenarios will require the subjects to "walk" straight ahead at a fixed rate of speed (2, 3, or 4 miles per hour) on a simulated fixed incline (-7.5, -5.0, -2.5, 0, +2.5, +5.0, or +7.5 degrees).

Task 6A.1.2. Develop and Test Experimental Control and Data Collection Software. This will require that the incline and speed sequences be programmed into the I-Port "Quick Fix" system, along with any automated data collection routines required.

Task 6A.1.3. Develop Experimental Procedures and Materials (data collection forms, instructions for Subjects, etc.). Equipment to monitor heart rate and VO2 consumption will need to be obtained. Forms for collecting background information, and the necessary documents for approval of the use for human subjects will need to be prepared. Commercial instruments for measuring heart rate and VO2 may need to be obtained.

Task 6A.1.4. Conduct Experiment.

Task 6A.1.5. Analyze Data.

Task 6A.1.6. Write Report.

Assessment Tasks: Experiment 6A.2

Task 6A.2.1. Develop Terrain Databases. Two terrain databases are required: the K-D Range and the obstacle course. Both will require a relatively high level of detail.

Task 6A.2.2. Develop and test Experimental Control and Data Collection Software.

Task 6A.2.3. Develop Experimental Procedures and Materials (data collection forms, instructions for Subjects, etc.) This should include the development of forms for collecting background information, and preparation of the necessary documents for approval of the use for human subjects.

Task 6A.2.4. Conduct Experiment.

Task 6A.2.5. Analyze Data.

Task 6A.2.6. Write Report.

## Task 6B. Upper Body Tracking

### Task Description

A tracking system is being developed which will be able to monitor the position of a simulated rifle more accurately. Current technology provides an accuracy comparable to a 59 inch dispersion at 100 yards, compared to a requirement for 4.6 inch dispersion and 100 yards, based on the accuracy of the M16 rifle. The new system will use cameras to monitor the positions of passive markers on the weapon.

### Assessment Issues

Does improved weapon system and upper body tracking accuracy affect the accuracy of simulated weapons firing or the soldier's perception of the accuracy of the simulated firing?

Does the improved tracking system affect soldier comfort or side effects?

### General Assessment Approach

A human in the loop experiment will be conducted to determine the effects of the improved tracking system (relative to a baseline system) on the accuracy of firing at simulated stationary and moving targets. The experiment would involve two groups of ten subjects each, with one group using the existing tracking system and one group using the new tracking system. Subjects will be stationary. Targets will be presented at four different distances (to be determined later) and will be stationary or moving at a constant speed in one of eight directions relative to the subject (with the subject facing 12 o'clock, the target would be moving toward either 12 o'clock, 1:30, 3 o'clock, 4:30, 6 o'clock, 7:30, 9 o'clock, or 10:30. Subjects will fire from the standing, kneeling, and prone positions.

Scenarios and Terrain Database

A target engagement scenario (probably a modification of a MOUT scenario) in the Quantico Combat Training Village.

Performance Measures

Percent hits
Perceived weapon system accuracy
Comfort and convenience questionnaires
Simulator Sickness Questionnaire

Assessment Tasks

Task 6B.1. Develop Target Engagement Scenario.

Task 6B.2. Develop and test Experimental Control and Data Collection Software. This software will control the presentation of the targets, record the time and accuracy of the subject's firing, and create a datafile for further analysis.

Task 6B.3. Develop Experimental Procedures and Materials (data collection forms, instructions for Subjects, etc.). This should include the development of forms for collecting background information, vision testing, and preparation of the necessary documents for approval of the use for human subjects.

Task 6B.4. Conduct Experiment.

Task 6B.5. Analyze Data.

Task 6B.6. Write Report.

## Resource Requirements and Availability

### Computer Systems

The relevant computer capabilities of each of the participating government organizations are shown in Appendix A. (The ARI computer is located at IST.) All use the Silicon Graphics Onyx Reality Engine as the principle component. However the systems are configured differently.

## Terrain Databases

The following terrain databases are required for the assessment.

Quantico Combat Training Village. NAWC-TSD has developed this database.

Open Terrain Databases. ARI has developed two two-kilometer square rural terrain databases. One represents no real area. The second roughly represents a section of the McKenna MOUT site at Fort Benning, GA.

Airbase. AL/HR is developing this database.

K-D Range. ARL/HRED is developing this model of the K-D Range, an actual obstacle course located at Aberdeen Proving Ground, MD.

Cross-Country Course. ARL/HRED is developing this model of an actual cross country course located at Aberdeen Proving Ground, MD.

## Cost Rationale

A cost estimate for the assessment is presented in Appendix B. This should be considered a rough estimate. It is not based on either detailed analysis by the participating organizations or the bids from contractors. The work to accomplish each task has been allocated between the government organization (NAWC-TSD, ARL/HRED, etc.) and a contractor, either a university (University of Central Florida, University of Pennsylvania) or a commercial firm (Sarcos Research, Boston Dynamics, Inc.). This is not intended to indicate how the work should be accomplished but rather only to provide a basis for cost estimation.

Two different man-hour costs were used. A staff year of 1840 hours was used. Government and University costs were based of the current NAWC-TSD of $90,000 per staff year, or $48.91 per hour. Commercial costs were based on a burdened cost (including indirect cost and overhead) of $130,000 per year, or $70.65 per hour.

Travel costs were based on current government airfares and per diem rates.

REFERENCES

Granieri, J. P., Crabtree, J., and Badler, N. I. (1995, February). Production and playback of human figure motion for 3D virtual environments. In Badler, N. I., Center for Human Modeling and Simulation Quarterly Progress Report No. 54. Philadelphia, PA: University of Pennsylvania.

Kennedy, R. S., Lane, N. E., Berbaum, K. S., and Lilienthal, M. G. (1993). A simulator sickness questionnaire (SSQ): A new method for quantifying simulator sickness. International Journal of Aviation Psychology, 3(3), 203-220.

Reece, D. A. (1994, December). Extending DIS for individual combatants. Paper presented at the 5th Annual Conference on AI, Simulation and Planning in High Autonomy Systems: DIS Environments. Gainesville, FL.

# APPENDIX A

## Computer Resources

# Appendix A. Computer Resources

| ***Specifications of each Organization's Silicon Graphics Onyx Machines:*** | | | | |
|---|---|---|---|---|
| | **ARL-HRED** | **ALHRG** | **NAWCTSD** | **ARI** |
| Version of IRIX OS | IRIX 5.3 | IRIX 6.0 | IRIX 5.3 | IRIX 5.3 |
| Number of Processors | 2 150 MHz w/additional 2 200 MHz on the way | 2 | 4 - 150 MHz | 4 |
| Serial Port Configuration | | | | |
| a. Total # of ports | | 3 | 4 | 10 |
| b. List of available ports | | 2 RS-232, 1 RS-422 | 2 RS-232 | |
| c. Ports RS-232 w/DB-9? | Yes | Yes | Yes | Yes |
| Does Onyx have Multi-Channel Option (MCO) ? | Yes | No, but it may in the future. | No | Yes |
| Number of Raster Managers | 2 | 2 | 2 | 4 |
| Disk Space Available | 3 Gigabytes | 9 Gigabytes | 1 Gigabyte | 2 and 1.2 Gigabytes |
| Amount of memory | 128 MB | 128 MB | 256 MB | 256 MB |
| Type of tape drive(s) | 1 8mm, DAT drive on order | 4mm SCSI | 2 units,type unknown | None |
| IRIS Performer Toolkit version # | IRIS Performer 1.2 | 1.2 for Irix 5.3 & 4.0.5 | IRIS Performer 1.2 | IRIS Performer 1.2 |
| MultiGen version # | Latest version running on SGI extreme. | Doesn't currently have MultiGen - considering Coryphaeus for next year. | | None |
| Is Onyx on net for ftp? | Yes | Yes | Yes | Yes |
| Is an additional serial terminal available for use after MCO mode is entered and the main monitor is dark/off? | Yes | | No | Yes |
| What type of visual display systems are available? | 27" monitor; Kaiser VIM HMD | 37 inch CRT & Projection device | Barco 1209 Rear Screen Projection | Virtual Research VR4 HMD; Fakespace Labs BOOM 2C; various monitors |
| What type of position tracking is available? How many sensors? | Polhemus Fastrac (4 sensors) | Flock of Birds (8 sensors) | | Polhemus Fastrak (4 sensors); Flock of Birds (6 sensors) |

# Appendix A. Computer Resources

| ***Requirements for Organization-Specific Applications:*** | | | | |
|---|---|---|---|---|
| | **ARL-HRED** | **ALHRG** | **NAWCTSD** | **ARI** |
| Version of IRIX OS | IRIX 5.3 | IRIX 5.2 or higher | IRIX5.3 | IRIX 5.3 |
| Number of processors | Minimum 2 | 1 | 4 | 2 (1 with degredation) |
| Number of Serial Ports Required | N/A | 0 | 2 | 3 |
| Multi-Channel Option (MCO) ? | N/A | Not currently used | Not currently used | Yes |
| Number of Raster Managers | 2 | 1 recommended | 2 | 4 |
| Disk Space Required | 200 MB | 500 MB recommended free space | 50MB with one database and one trainee | 20MB + 5 MB per trainee |
| Amount of Memory | 64 MB | 32 MB minimum | 64 MB | 128MB minimum |
| IRIS Performer toolkit version # | IRIS Performer 1.2 | IRIS Performer 1.2 | IRIS Performer 2.0 | IRIS Performer 1.2 |
| MultiGen version # | N/A | Not currently required | | 14.1 (not required to run) |
| What type of visual display systems are required? | Standard SGI Graphics Monitor | Graphics Monitor, 1280 x 1024 | Rear projector & screen (currrently Barco 1209) | Graphics Monitor, 1280 x 1024 |
| What type of position tracking is used? How many sensors? | Polhemus Fastrak (2 sensors) | Flock of Birds (8), CyberGlove (or Dataglove), Crystal Eyes | Flock of Birds (1) | Flock of Birds (4 sensors) for current gesture set. |
| Any software required besides IRIS and Performer? | NPSNET, distributed free by Naval Postgraduate School | No | No | No |
| Any especially configured hardware required? | No | 24-bit Z-buffered graphics. An Indigo 2 XZ is good enough for some of the user's applications. | Custom made weapons interface | Special chord-type glove, voice recognition card (Dragon Speak), a 486 PC w/ networking capability,30 MB of disk space,DOS 6.22 |

# APPENDIX B

## ICSS Assessment Cost Estimate

# Appendix B. ICSS Assessment Cost Estimate

| TASK NO. | Manhours Government | Manhours University | Manhours Commercial | Labor Cost | Travel Cost | Total Cost | Calendar Time (Wks) |
|---|---|---|---|---|---|---|---|
| 1A.1 | 40 | 400 | | $21,520.40 | | | 10 |
| 1A.2 | | 80 | | $3,912.80 | | | 2 |
| 1A.3 | 40 | 40 | | $3,912.80 | | | 2 |
| 1A.4 | 80 | 80 | | $7,825.60 | | | 3 |
| 1A.5 | 40 | 120 | | $7,825.60 | | | 4 |
| 1A.6 | 40 | 160 | | $9,782.00 | | | 8 |
| Total 1A. | 240 | 880 | 0 | $54,779.20 | $5,360.00 | $60,139.20 | |
| | | | | | | | |
| 1B.1 | 60 | 120 | | $8,803.80 | | | 5 |
| 1B.2 | | 160 | | $7,825.60 | | | 4 |
| 1B.3 | 20 | 40 | | $2,934.60 | | | 2 |
| 1B.4 | 40 | 40 | | $3,912.80 | | | 3 |
| 1B.5 | 40 | 40 | | $3,912.80 | | | 2 |
| 1B.6 | 40 | 80 | | $5,869.20 | | | 4 |
| 1B.7 | 40 | 160 | | $9,782.00 | | | 8 |
| Total 1B | 240 | 640 | 0 | $43,040.80 | $1,986.00 | $45,026.80 | |
| | | | | | | | |
| 2.1.1 | 40 | 160 | | $9,782.00 | | | 5 |
| 2.1.2 | | 80 | | $3,912.80 | | | 2 |
| 2.1.3 | 40 | 40 | | $3,912.80 | | | 4 |
| 2.1.4 | 160 | 80 | | $11,738.40 | | | 4 |
| 2.1.5 | 120 | 40 | | $7,825.60 | | | 4 |
| 2.1.6 | 160 | 40 | | $9,782.00 | | | 8 |
| Total 2.1 | 520 | 440 | 0 | $46,953.60 | | $46,953.60 | |
| | | | | | | | |
| 2.2.1 | 40 | 40 | | $3,912.80 | | | 2 |
| 2.2.2 | | 40 | | $1,956.40 | | | 2 |
| 2.2.3 | 20 | 20 | | $1,956.40 | | | 4 |
| 2.2.4 | 120 | 40 | | $7,825.60 | | | 4 |
| 2.2.5 | 120 | 40 | | $7,825.60 | | | 4 |
| 2.2.6 | 160 | 40 | | $9,782.00 | | | 8 |
| Total 2.2 | 460 | 220 | 0 | $33,258.80 | | $33,258.80 | |

# Appendix B. ICSS Assessment Cost Estimate

| TASK NO. | Manhours Government | Manhours University | Manhours Commercial | Labor Cost | Travel Cost | Total Cost | Calendar Time (Wks) |
|---|---|---|---|---|---|---|---|
| 4.1.1 | 40 | 200 | | $11,738.40 | | | 6 |
| 4.1.2 | 40 | 120 | | $7,825.60 | | | 4 |
| 4.1.3 | 40 | 40 | | $3,912.80 | | | 4 |
| 4.1.4 | 160 | 160 | | $15,651.20 | | | 4 |
| 4.1.5 | 40 | 120 | | $7,825.60 | | | 4 |
| 4.1.6 | 40 | 160 | | $9,782.00 | | | 8 |
| Total 4.1 | 360 | 800 | | $56,735.60 | $5,739.00 | $62,474.60 | |
| | | | | | | | |
| 4.2.2 | | 80 | | $3,912.80 | | | 2 |
| 4.2.3 | 40 | 40 | | $3,912.80 | | | 4 |
| 4.2.4 | 80 | 80 | | $7,825.60 | | | 3 |
| 4.2.5 | 40 | 120 | | $7,825.60 | | | 4 |
| 4.2.6 | 40 | 160 | | $9,782.00 | | | 8 |
| Total 4.2 | 920 | 2080 | 0 | $146,730.00 | $2,664.00 | $149,394.00 | |
| | | | | | | | |
| 5.1 | | 80 | | $3,912.80 | | | 6 |
| 5.2 | | 240 | | $11,738.40 | | | 12 |
| Total 5 | 0 | 320 | 0 | $15,651.20 | | $15,651.20 | |
| | | | | | | | |
| 6A.1.1 | 40 | | | $1,956.40 | | | 2 |
| 6A.1.2 | 40 | | | $1,956.40 | | | 2 |
| 6A.1.3 | 80 | | | $3,912.80 | | | 4 |
| 6A.1.4 | 80 | | | $3,912.80 | | | 2 |
| 6A.1.5 | 160 | | | $7,825.60 | | | 4 |
| 6A.1.6 | 200 | | | $9,782.00 | | | 8 |
| Total 6A.1 | 600 | 0 | 0 | $29,346.00 | | $29,346.00 | |

# Appendix B. ICSS Assessment Cost Estimate

| TASK NO. | Manhours Government | Manhours University | Manhours Commercial | Labor Cost | Travel Cost | Total Cost | Calendar Time (Wks) |
|---|---|---|---|---|---|---|---|
| 6A.2.1 | 80 | | 920 | $68,910.80 | | | 16 See Note 1 |
| 6A.2.2 | 120 | | | $5,869.20 | | | 4 |
| 6A.2.3 | 80 | | | $3,912.80 | | | 4 |
| 6A.2.4 | 160 | | | $7,825.60 | | | 4 |
| 6A.2.5 | 160 | | | $7,825.60 | | | 4 |
| 6A.2.6 | 200 | | | $9,782.00 | | | 8 |
| Total 6A.2 | 800 | 0 | 920 | $104,126.00 | | $104,126.00 | |
| 6B.1 | 40 | | 120 | $10,434.40 | | | 4 |
| 6B.2 | 40 | | 40 | $4,782.40 | | | 2 |
| 6B.3 | 40 | | 40 | $4,782.40 | | | 4 |
| 6B.4 | 80 | | 80 | $9,564.80 | | | 4 |
| 6B.5 | 40 | | 120 | $10,434.40 | | | 4 |
| 6B.6 | 40 | | 160 | $13,260.40 | | | 8 |
| Total 6B | 280 | 0 | 560 | $53,258.80 | $3,706.00 | $56,964.80 | |
| Lessons Learned | | | | | | | |
| | 560 | 600 | 160 | $68,039.60 | $4,692.00 | $72,731.60 | |
| Grand Total | | | | $651,919.60 | $24,147.00 | $676,066.60 | |

Note 1. Task 6A.2.1. requires multiple contractor personnel.

# ICSS Assessment Cost Estimate: Travel Costs

| Airfares | |
|---|---|
| Orlando to Washington, DC | $398.00 |
| Philadelphia, PA to Dayton, OH | $338.00 |
| Orlando to Philadelphia, PA | $402.00 |
| Orlando to Boston, MA | $342.00 |
| Orlando to Salt Lake City, UT | $630.00 |
| Orlando to Baltimore, MD | $364.00 |

| Per Diem Rates | Room | Meals | Total |
|---|---|---|---|
| Quantico, VA | $55.00 | $26.00 | $81.00 |
| Dayton, OH | $63.00 | $20.00 | $91.00 |
| Philadelphia, PA | $89.00 | $34.00 | $123.00 |
| Orlando. FL | $68.00 | $26.00 | $94.00 |

| | |
|---|---|
| 1A. Phila to Orlando. 1 person, 5 days, 5 trips | $5,360.00 |
| 1B Phila to Dayton, 1 person, 5 days, 2 trips | $1,986.00 |
| 2.1 No travel | |
| 2.2 No travel | |
| 4.1 Orlando to Quantico, 3 persons, 5 days, 3 trips | $5,739.00 |
| 4.2 Quantico to Orlando, 1 person, 2 days, 4 trips | $2,664.00 |
| 5 No travel | |
| 6A.1 No travel | |
| 6A2. No travel | |
| 6B.1 Orlando to Quantico, 3 persons, 5 days, 2 trips | $3,706.00 |
| Lessons Learned | |
| Baltimore to Orlando, 1 person, 2 days, 1 trip | $632.00 |
| Philadelphia to Orlando, 2 persons, 2 days, 1 trip | $1,280.00 |
| Quantico to Orlando, 1person, 2 days, 1 trip | $666.00 |
| Boston to Orlando, 1 person, 2 days, 1 trip | $610.00 |
| Dayton to Orlando, 1 person, 2 days, 1 trip | $606.00 |
| Salt Lake City to Orlando, 1 person, 2 days, 1 trip | $898.00 |
| Total Lessons Learned | $4,692.00 |
| Total Travel | $24,147.00 |

## APPENDIX C: LIST OF ACRONYMS

AL/HR ............ US Air Force Armstrong Laboratory, Human Resource Directorate
ARI ............... US Army Research Institute for the Behavioral and Social Sciences
ARL-HRED ........ US Army Research Laboratory, Human Research and Engineering Directorate
CCHC ............. Computer Controlled Hostile Combatants
CCHC/N ........... Computer Controlled Hostile Combatants and Neutrals
CGF .............. Computer Generated Forces
CGFT ............. Computer Generated Forces Testbed
DIS ............... Distributed Interactive Simulation
DOD .............. Department of Defense
DOF .............. Degrees of Freedom
ICSS .............. Individual Combatant Simulation System
ISMS ............. Individual Soldier Mobility Simulator
IST ............... University of Central Florida Institute for Simulation and Training
MARCORSYSCOM . US Marine Corps Systems Command
MILES ............ Multiple Integrated Laser Engagement System
MOBA ............ Military Operations in Built-up Areas
MOUT ............ Military Operations in Urban Terrain
NAWC-TSD ....... US Naval Air Warfare Center Training Systems Division
PDP .............. Program Development Plan
PDU .............. Protocol Data Unit
ROTC ............. Reserve Officers Training Corps
SAFOR ............ Semi-automated Forces
SME .............. Subject Matter Expert
SSQ .............. Simulator Sickness Questionnaire
TTES ............. Team Target Engagement Simulator
VE ............... Virtual Environment
VR ............... Virtual Reality